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Review article

Russian olive (*Elaeagnus angustifolia* L.): From a variety of traditional medicinal applications to its novel roles as active antioxidant, anti-inflammatory, anti-mutagenic and analgesic agent



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ABSTRACT

Elaeagnus angustifolia L., which is commonly known as oleaster or Russian olive, is a deciduous plant from *Elaeagnaceae* family. This plant can tolerate and survive a wide variety of environmental conditions. Different parts of *E. angustifolia* plant, especially the fruits and flowers, have been used traditionally in treating a variety of common illnesses such as nausea, cough, asthma, fever, jaundice, and diarrhea. The use of fruit powder and extract of *E. angustifolia* L. have shown to be effective in alleviating pain in patients with rheumatoid arthritis and also in reducing the healing time of wounds in injured person. In addition, some recent reports have indicated the anti-oxidant, anti-inflammatory, antimicrobial, anti-cancer and some other properties of oleaster plant. The other important property of this plant would be its role in bio-monitoring the environment for some toxic elements and also its action as a bio-fertilizer agent in distressed lands. It seems that with more advanced studies on *E. angustifolia* L. and its bioactive components, this plant might be potentially effective and can be used as a natural alternative resource in pharmaceutical industries for treating chronic and serious problems, Fig. 1.

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1. Introduction

Elaeagnus angustifolia L. (oleaster, Russian olive, Wild olive) belongs to the genus *Elaeagnus* of *Elaeagnaceae* (*Araliaceae*) family.¹ There are more than 90 species of the *Elaeagnus* found around the world which are mainly distributed in subtropical regions of Asia, Europe and some parts of North America.² *E. angustifolia* L. is a deciduous tree or large shrub which is commonly called Russian

olive since its appearance resembles an olive tree with small reddish-brown, elliptic shaped fruits.³

Russian olive is a long lived tree (80–100 years) which grows rapidly up to 10 m in height and 30 cm in diameter and starts to fruit after 5–6 years.⁴ This tree can tolerate a wide range of harsh environmental conditions such as flood, severe drought, stony, sandy and high salinity or alkalinity of the soils.⁵ Different parts of the Russian olive plant have been used in a variety of medicinal formats, in perfume industries, as well as in wood-work and musical instruments production.⁴

Russian olive fruits have high nutritional values and contain proteins, sugar, vitamins and minerals.^{3,6} The flowers are small, fragrant, and a yellowish-white color and have been used as a source of nectars for honey bees, as well as a flavoring agent in liqueur production.^{3,4} The flowers have also been used to treat tetanus in traditional medicine.⁷

The decoction and infusion of the fruit, flower, leaf and bark of *E. angustifolia* L. have been used traditionally to treat a variety of illnesses and their symptoms. The raw or boiled fruit is consumed for

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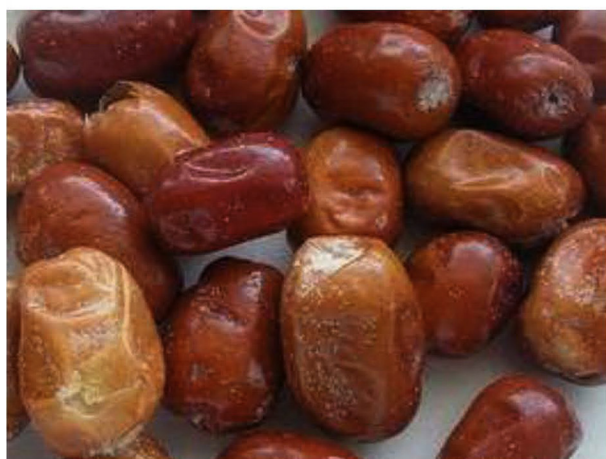
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Senedj Type 1



Senedj Type 2

Fig. 1. Photo by Pars Bioscience, LLC, Leawood Kansas.

the treatment of sore throat, cough, flu, cold, fever, nausea, vomiting, jaundice, asthma, diarrhea and some other symptoms and diseases.^{5,8,9} In Iranian folk medicine, fruits have been used for the relief of pain and inflammation in patients with rheumatoid arthritis and for accelerating the wound healing process in an injured area.¹

Recent pharmacological studies have shown that *E. angustifolia* L. has anti-inflammatory, antimicrobial, anti-oxidant and some other health benefits which might be used for treating a number of distresses.⁷

2. Composition

The fruits of *E. angustifolia* L. have been traditionally consumed fresh or dried as a rich source of vitamins such as tocopherol, carotene, vitamin C, thiamine B1, and minerals such as calcium, magnesium, potassium, iron and manganese.¹⁰ The studies have shown that the different parts of *E. angustifolia* L. contain different concentrations of minerals. The root, root bark, branches, stem bark and leaves contain iron, lead, copper, cadmium, zinc, chromium, nickel and cobalt.¹¹ The most abundant mineral found in *E. angustifolia* L. fruit is potassium (8504 mg/kg), followed by sodium (1731 mg/kg) and phosphorus (635 mg/kg).¹² Exposure to the previously mentioned metals may result in chronic pulmonary disease, nephrotoxicity, cancer, renal toxicity and disease, hypertension, hyperglycemia, and other health problems, but only in high-level, long-term exposure.⁴⁶

Phytochemical studies of *E. angustifolia* L. fruit extract indicate the presence of flavonoid compounds, polysaccharides, sitosterols, cardiac glycosides, terpenoids, coumarines, phenol carboxylic acids, amino acids, saponins, carotenoids, vitamins, and tannins.^{8,13,14} Flavonoids which are mainly present in fruits and vegetables, due to their phenolic hydroxyl groups, are able to chelate metals, reduce lipid peroxidation and have shown a high antioxidant and free radical scavenging activities.¹³

A group of flavonoids such as 4 (+)-catechin, (-)-epicatechin, (+)-gallocatechin, (-)-epigallocatechin, kaempferol, quercetin, luteolin, isorhamnetin and isorhamnetin-3-O- β -D-galactopyranoside have been isolated and identified from the extract of *E. angustifolia* L.¹³

The most abundant phenolic compounds found in *E. angustifolia* L. plants, are known to be 4-hydroxybenzoic acid from the benzoic group (45.8 mg/100 g dry weight [wt.]) and caffeic acid from the cinnamic group (32 mg/100 g dry wt.).¹⁴ Among soluble sugars; fructose (27.1% dry wt.) and glucose (22.3% dry wt.) were found to be the major monosaccharide responsible for the sweet taste of *E. angustifolia* L. fruit along with phenolic compounds.¹⁴

E. angustifolia L. contains a high amount of condensed tannins.¹⁵ The contents of condensed tannins are variable among different parts of the plant. Bark of the tree has the maximum amount of tannins, followed by the leaves and annual branches.¹⁵

In many studies, the health benefits of condensed tannins which are present in teas, red wines and some fruits and vegetables, have been proven. Tannins have been shown to have anti-cholesterol, anti-inflammatory, anti-cancer, cardioprotective and chemopreventive effects in our body, and in addition increase the angiogenesis activities in the wounded area of skin tissues which assist to lessen the healing time.¹⁵

In the study, some fatty acids such as, lauric, tridecanoic, myristic, pentadecanoic, palmitic, palmitoleic, heptadecanoic, linoleic, linolenic, oleic, stearic, eicosanoic, and docosanoic acids were identified in the extract of the fruit of *E. angustifolia* L.¹⁶ The study shows that major fatty acids in the samples were palmitic acid (34.31%) followed by oleic acid (26.23%) and lignoceric (17.47%).¹⁷ An abundance of palmitoleic acid in fruit skin and a high amount of linoleic acid and palmitic acid in seeds of *E. angustifolia* L. was reported in the study, which might be explained through the differences in genotypes, climatic condition and soil composition variation.¹⁷

In conclusion, *E. angustifolia* L. fruit is a rich source of some nutrients, minerals, chemical compounds and antioxidants useful for the human health.¹²

3. Applications

3.1. Wound healing effects

In response to the injury, wound healing is an essential and active process which will return the function back to the damaged tissue and contains four precise and highly programmed phases.⁸ These phases include; hemostasis (stop of the bleeding), inflammation, proliferation, and tissue repairing. Following the hemostasis process, the inflammation phase of wound healing is an essential part for the elimination of the infectious micro-organisms, release of the healing factors to the wounded area, and also facilitating the migration and division of cells for the proliferative phase. It is important that the inflammatory response time be short since the continual of inflammation phase can stop the healing process.⁸

The proliferative phase basically involves the deposition of a protein called collagen in the tissue, which is a major part of connective tissue¹⁸ and has an important role in healing the wounds and repairing the tissue.¹⁹

The major component of collagen is hydroxyproline, which is the key indicator of collagen biosynthesis in the tissue and is made of pro and hydroxypro amino acids. Hydroxyproline, with its cyclic arrangement, provides structure and strength to the collagen and collagen gives strength to the tissue and, at the later stage, helps in the re-epithelization process.²⁰ The finding of the study indicates that after applying the extract of the fruit of *E. angustifolia* L. to the wounded area, the content of hydroxyproline, an important factor in making collagen, was increased in the tissue.^{8,21} In addition, another study shows that *E. angustifolia* L. fruit extracts has a significant effect in accelerating the wound healing process and reducing the inflammation and pain in rats.⁸

In Iranian traditional medicine, dried powdered leaves of oleaster (Persian; *Senjed*) have been used as a remedy to control bleeding and accelerate the wound healing process.^{8,22} The study shows that the application of the oleaster leaves extract (OLE) decreases the area of wound significantly and highly increases the number of capillary buds and fibroblasts in treated group compared to the control group. Fibroblasts are the adhering cells in skin connective tissue and play an important role in the wound healing process.²²

The contents of flavonoids and antioxidants of *E. angustifolia* L. extract are important factors in wound healing process. Flavonoids are known for their antimicrobial activities which help to increase the speed of wound closure and regeneration of epidermis in the skin.⁸ Antioxidants have an essential role in protecting tissues from oxidative damages and significantly promote DNA synthesis in wound healing progression. Further phytochemical studies can determine and isolate the active components and mechanism of action responsible for the pharmacological properties of this plant, which could be used as a therapeutic agent in wound healing process for the future.⁸

3.2. Gastro-intestinal [GI] healing

The preparations of oleaster fruits are widely used in some parts of Europe and Central Asia for the treatment of peptic ulcer since these extracts increase the formation of wound healing tissue in the intestines.²³ In this study, the carotenoid fraction of the fruit oil proved to have a protective effect against GI ulcers.²³

The result of another study suggests that after applying the methanolic fruit extract of *E. angustifolia* L. in rats with ethanol-induced ulcer, a strong gastroprotective activity was observed in the tissue after conducting the histopathological examination and ulcer index determination.²⁴ Also a drug called pshatin which is made of *E. angustifolia* L., a concentration of the fruit polyphenolic compounds, has been used for a long time for the treatment of colitis and other GI tract diseases in Armenia.²⁵ Further studies are suggested on the pharmacological aspects and mechanism of actions of *E. angustifolia* L. extract on neurons, in addition to the inhibitory effects of the extract on vascular and respiratory smooth muscle cells (SMC). The advanced phytochemical studies would facilitate and determine the major substances incorporated in variety of biological activities of this plant.²⁴

3.3. Muscle relaxant activity

The fruit, leaf and flower extracts of *E. angustifolia* L. have been used traditionally for the treatment of various muscle pain related ailments. The use of oleaster flower to treat tetanus in folk medicine can also be the indication of the muscle relaxant activity of this plant.²⁶

In the study, the muscle relaxant activity of aqueous and ethanol extracts of the *E. angustifolia* L. fruit seeds was examined, using traction test in mice. The result showed that with the increased

dosages of the extracts, the muscle relaxant property of the tissue was also increased. In higher dosages, the effectiveness of the aqueous and ethanol extracts was similar to diazepam (2 mg/kg), a chemical drug used for relieving tension and relaxing the muscles.²⁶

The muscle relaxant activity of *E. angustifolia* L. might be due to the effect of some flavonoids or flavones components such as chrysin which have partial agonistic effect on benzodiazepine receptors.²⁶ More studies are needed to explain the mechanism of interaction between the active components of the plant extracts and the receptors.

This report initiated another study on the effect of leaf and flower extract of *E. angustifolia* L. on the activity of gastrointestinal smooth muscles. The results demonstrated that the activities of some isolated smooth muscle cells were inhibited by the *E. angustifolia* L. extract which may be a reason for the beneficial effects of *E. angustifolia* L. in the treatment of nausea, vomiting, and flatulence. Although these symptoms are motor related functions and could be under the control of nervous system, it is difficult to figure out whether the beneficial effects of *E. angustifolia* L. to treat these diseases is due to the direct effect on the contraction of smooth muscle cells or by the neural control of gastrointestinal motor functions.²⁴

3.4. Antioxidant activity

The toxic and dangerous side effects of many synthetic antioxidants and the tremendous benefit of natural antioxidants and phenolic compounds found in fruits, vegetables and dietary antioxidants, have raised the interest of many people toward the consumption of more natural antioxidants in their diets, for improving the quality of their lives and reducing the risk of many diseases.²

The active compounds of natural sources such as phenolic and flavonoids compounds which can be found in the fruit, flower, seeds and leaves of many plants have shown to have antioxidant activities due to their ability to release the electrons and scavenge the free radicals.² Many factors such as climate, soil and ecological conditions are involved in the amount of these plants secondary metabolites.²

The extracts of leaves and flowers of *E. angustifolia* L. contain phenolic and flavonoid compounds which have antioxidant properties and protect cells from oxidative damages and delays or reduce the risk of many degenerative diseases.² The studies have shown that the amounts of phenolic and flavonoid compounds are higher in leaves than flower of the plant. The explanation might be due to the process of photosynthesis which occurs in the leaves and also the existence of high amount of flavonoid biosynthetic pathway precursors in the leaves than any other organs.²

As the studies have shown *E. angustifolia* L., is consist of various chemical compounds including amino acids, flavonoids, phenolic compounds, polysaccharides and some other essential elements. The polysaccharides are important component of *E. angustifolia* L. with anti-radiation, antioxidant and immune regulatory activities. To examine the characterization and antioxidant activity of the polysaccharides of *E. angustifolia* L., two polysaccharides (*E. angustifolia* L. polysaccharide-1 (PEA-1) and (PEA-2)) were prepared and studied from the fruits of this plant.²⁷ The result of this study demonstrated the strong antioxidant activity of PEA-1 and PEA-2 *in vitro* with moderate scavenging properties and lipid peroxidation inhibition effect. Further studies are required to evaluate the safety and potential usage of this plant for the development of some new natural remedies.²⁷

In the study, four flavonoid compounds were isolated and identified as Quercetin 3,4'-O- β -D-diglucoside (1), Isorhamnetin-3-

O- β -D-galactopyranoside (2), Quercetin 3-O- β -D-Galactopyranoside-4'-O- β -D-glucopyranoside (3) and Isorhamnetin 3-O- β -D-Galactopyranoside-4'-O- β -D-glucopyranoside (4).⁷ In this study, the antioxidant activity of these flavonoid glycosides was evaluated and the result showed that each of these compounds have a concentration-dependent antioxidant activity and among them Quercetin 3,4'-O- β -D-diglycoside (1) has higher antioxidant activity than the others.⁷

3.5. Cardioprotective activity

Heart attack or acute myocardial infarction (MI) is one of the top causes of death among cardiovascular diseases. Sometimes a partial or complete blockage of the heart arteries can cause the decrease of blood flow to the heart muscle which is called myocardial or cardiac ischemia. This can damage the heart muscle, reducing its ability to pump efficiently and decrease the heart's oxygen supply. The most effective way to reduce the heart injury is the quick return of the blood supply to the heart. Strangely enough, the return of blood supply to the tissue after a period of time can also do harm to the heart by causing inflammation and oxidative stress damage to the tissue, which is called myocardial ischemia-reperfusion (I/R) injury. A range of studies have shown that some antioxidants, such as vitamin E, catalase (CAT), melatonin, and superoxide dismutase (SOD) can have protective effect against I/R injury.²⁸

The beneficial effects of antioxidants on providing the resistance to the heart tissue against the ischemic-reperfusion injury have been recorded in several studies. Myocardial antioxidants can reduce or interrupt the oxidative damages to the sub cellular proteins, carbohydrates, lipids and DNA.²⁹ The mechanism of action of antioxidants might be through: inhibiting the reactive oxygen species (ROS) formation, scavenging ROS or their precursors, developing endogenous antioxidant generation and reducing the cell death by increasing the anti-death gene.²⁹

In the study the effectiveness of aqueous extract of the *E. angustifolia* L. leaves and its cardioprotective activity in induced ischemia/reperfusion (I/R) was demonstrated in isolated rat heart. The result showed that *E. angustifolia* L. at the dosages of 0.5 mg/mL and 1.0 mg/mL significantly improved the restoration of the cardiac function and myocardial biochemical values toward the normal amount.²⁸ This result can indicate that the extract leaves of *E. angustifolia* has a protective effects on myocardial ischemia reperfusion injury which can be connected to the increase of antioxidant activity by the extract in the myocardial tissue.²⁸

3.6. Antinociceptive & anti-inflammatory effects

In search for new analgesic drugs with less harmful effects, it is logical to look into the medicinal plants which have been used traditionally for many years. Oleaster has been used from ancient times in Iranian folk medicine for its pain relieving and anti-inflammatory properties. The phytochemical studies of *E. angustifolia* L. fruit extract indicates that flavonoids and terpenoids are considered to be the main components for the analgesic and anti-inflammatory effects of *E. angustifolia* L. fruit extract.²⁴

Many studies have shown that the use of aqueous extract of *E. angustifolia* L. fruit is effective in reducing the pain and inflammation in animal models and also in patients with atherosclerosis. The extract has the ability to inhibit the activity of cyclooxygenase type1 and type2 enzymes and it seems to be a right candidate for becoming a good anti-inflammatory drug as well.³⁰

The report of the study shows that the effectiveness of extract of *E. angustifolia* L. to reduce the chronic pain and inflammation (caused by formalin injection) is comparable to the chemical drugs such as indomethacin, a nonsteroidal anti-inflammatory drug

(NSAIDs) and dexamethasone which is a steroid medication used as an anti-inflammatory and immunosuppressant drug.³⁰ Indomethacin act through the inhibition of cyclooxygenase type1 and 2 enzymes and dexamethasone play a role in inhibiting the phospholipase A2 enzyme activities. The result of *in vitro* study indicates that extract of *E. angustifolia* L. has the inhibiting effect on cyclooxygenase type1 and type2 enzymes which is comparable to indomethacin and since the result did not show any harsh effects on mucous membrane of the gastrointestinal tract, it seems *E. angustifolia* L. extract could be a good candidate as a natural anti-inflammatory drug for the relief of chronic pain in humans.³⁰ Although the exact mechanism of action is not clear, the studies of the fruit and seed extract of *E. angustifolia* L. have shown that the extract has anti-inflammatory and antinociceptive effects in rats.³⁰ Recent studies suggest that flavonoids and sitosterols are responsible for anti-inflammatory and analgesic effects of the plant.⁸

The study on the use of *E. angustifolia* L. in the patients with the oral lichen planus (OLP), which is an oral chronic inflammatory disease with rash-like symptoms, has shown that the topical use of 19% aqueous gel of *E. angustifolia* L. has a pain relieving, inflammation reducing and healing effect on these symptoms.⁶ Although the use of topical or systemic corticosteroids can have therapeutic effects in treating the disease, however, there are some side effects such as fungal infections, adrenal suppression, malignancy and headache associated with the use of these medications. Due to these adverse reactions, the search for a new kind of treatment and substitute, with minimum side effects has always been in consideration.⁶

There have been many biological studies associated with the finding of a safer and more effective way in alleviation of the pain in many patients. The report shows that in addition to the relative high cost of these pain medications, there are many side effects associated with taking these drugs, such as digestive system's problems, delayed wound healings, increased risk of infections and dependency to the drugs.³⁰

3.7. Osteoarthritis

Traditionally in Iran, Russian olive has been brewed and used as an analgesic agent to relieve pain in rheumatoid arthritis patients.² The studies have shown that the flavonoid components of the extract have antinociceptive and anti-inflammatory effects. The addition of muscle relaxation activity of the extract also makes it a proper treatment for some musculoskeletal disorders.³¹

Osteoarthritis is a painful chronic joint disorder which usually progresses with age. To relieve the pain and discomfort, commonly a nonsteroidal anti-inflammatory drug analgesics (NSAIDs) or selective cyclooxygenase-2 (COX-2) inhibitors and intra-articular therapies might be used, which some adverse reactions associated with the use of these drugs can take place. The use of alternative therapy such as herbal medicine in treating chronic pain disorders have shown to be beneficial in patients suffering from these diseases. There are some reported beneficial effects related to the relief of pain and inflammation after using the combined ginger and *E. angustifolia* L. fruit extracts in a newer trial. The report indicates that patients taking 200 mg of *E. angustifolia* L. fruit and ginger extracts for eight weeks have shown significant improvement in their pain intensity and pain occurrence.³² The result of this study suggests that the combination of ginger and Russian olive extracts are safe and can be effective in reducing pain in patients suffering from osteoarthritis. Further studies in the effect of different dosages and duration are suggested.³²

3.8. Memory

Alzheimer's disease is characterized by the impairment of cognitive and memory functions which are usually caused by the decreased activity of the cholinergic system. In the study by Morris water test the effect of water extract of *E. angustifolia* L. was examined in rats which their memory and learning were temporarily impaired by the scopolamine injection. The result showed that with the increased intake of the *E. angustifolia* L. water extract, the spatial learning and memory of the scopolamine induced rats improved dose dependently.^{33,34}

3.9. Anti-tumor activity

There are several species of *Elaeagnus* family which are known for their cytotoxic activities against cancer cells such as *E. angustifolia* L., *Elaeagnus umbellata*, *Elaeagnus pungens* and *Elaeagnus glabra*. There are some bioactive components like triterpenoid, flavonoid, lignanoid and benzenoid isolated from these species which could be responsible for their antitumor activities.³⁵

In an experiment the antioxidant and anti-tumor activity of different fractions of acetic ether extract of *E. angustifolia* L. was studied. With the increase of concentration and polarity level of each sample the antioxidant and radical scavenging activities increased relatively. The study shows that there is a significant inhibitory effect on the proliferation of Hela cells *in vitro* with the use of higher concentration of *E. angustifolia* L. extract.^{36,37}

The essential part of tumor growth and metastasis depends on angiogenesis (the formation of new blood vessels). In the study the effect of *E. angustifolia* L. hydroalcoholic extract on human umbilical endothelial cells (HUVEC) showed that the extract of *E. angustifolia* L. flower in 200 µg/ml could inhibit angiogenesis activity of HUVEC, therefore the extract can be a good candidate for preventing and treating angiogenesis related disorders.^{38,39}

3.10. Antimicrobial activity

During the recent years, due to the increased rate of illnesses caused by antibiotic-resistant microorganisms, the importance of using better alternatives such as medicinal plants with their natural antimicrobial activity has grown significantly.⁴⁰

Some medicinal plants and their components can potentially be a good source for being used as an anti-microbial agent. The first step toward the development of these plant-based antimicrobial agents would be the screening of the plants for their antimicrobial activities *in vitro*. The study of *E. angustifolia* L. showed that the MCI (minimum inhibitory concentration) value of the fruit extract which indicates the antimicrobial activity against the targeted culture being ranged between 0.1 mg/mL to 7.5 mg/mL. Above all, strong antimicrobial activity with MIC of 1.62 mg/mL against *Escherichia coli* was shown in this study. The report signifies the presence of promising antimicrobial agents in the *E. angustifolia* L. fruit extracts.⁴⁰

The antimicrobial activity of methanol extract of *E. angustifolia* L. leaves was evaluated *in vitro* against some microorganisms and the result of the study showed that the extract was highly effective against the growth number of Gram positive and negative bacteria such as *Bacillus subtilis* RSKK 245, *Staphylococcus aureus* RSKK 2392, *Salmonella typhimurium* RSKK19 and specially *Yersinia enterocolitica* NCTC 11174. In these studies the antimicrobial activity was evaluated with the standard antibiotics.³⁴ In another study, the leaf extract of *E. angustifolia* L. has shown to have a 42% positive inhibitory effect on *S. typhimurium* TA 100.¹³ Further studies are required for finding the compounds responsible for the antimicrobial activity of the extract in targeted cultures.⁴⁰

3.11. Bio-monitor activity

For many years, the pollution of water with harmful wastes and heavy metals produced by a different range of industrial activities has been a major concern, due to their toxic effects on the wellbeing of environment, agriculture and humans. Since most of the heavy metals such as Ni, Cd, Hg, Zn, Pb and Cr are not biodegradable and are toxic, they accumulate over time in living organisms causing a number of illnesses and disorders.⁴¹

The deposition, accumulation and distribution of metal pollution have been detected by some plant materials such as fungi, lichens, mosses and also plant leaves. In a past few decades mostly higher plant leaves have been used for bio-monitoring of the heavy metals pollution in the environment.⁴²

Since *E. angustifolia* L. can tolerate a wide range of geographical and environmental conditions as well as being able to differentiate between the airborne and soil borne heavy metals and also can be easily sampled for the purpose of identifying the pollutants, then it can be a good candidate to be used as a bio-monitor agent for screening the heavy metals.⁴²

Besides the growing number of industries and the environmental concern about the pollution of water resources by heavy metals, bio-monitoring and removing the toxins from the water are critical. Most of the methods such as ion exchange, coagulation, adsorption and electrochemical deposition are very costly. The more affordable way to eliminate these contaminants from the aqueous solutions is by bio-absorption method or the use of agricultural waste materials such as rice straw, sawdust, tobacco dust, orange, apple, or carrot residues, coconut shell powder, castor leaves powder, and etc. In adsorption method the molecules of adsorbate are attracted to the surface of adsorbent until the balance is achieved between adsorbent and adsorbed molecules.⁴¹

In an experiment the adsorption potential of Cr (VI), Cd (II) and Ni (II) by *E. angustifolia* L. fruit powder in aqueous solution was studied and the result suggested that this natural Bio-absorbent was effective in removing the pollutants and it depended on pH, adsorbent dosage and contact time.⁴¹

3.12. Nitrogen fixation (bio-fertilizer) activity

Planting nitrogen-fixing tree species on the distressed lands or inter-planting them with some other crops is a common way to increase the nutrient supplies and bring the productivity back to the region.⁴³

E. angustifolia L. which is a salt-tolerant and native to the Central Asia has been used for a long time for many purposes such as fruit, firewood, nectar and honey production, and also for medicinal purposes. *E. angustifolia* L. is able to cultivate and spread in wide range of climatic and soil conditions especially in distressed areas.⁴³

In an experiment, the nitrogen-fixation property of *E. angustifolia* L. in a mixed plantation with a few non-fixing plants was studied in saline and phosphorous-deficient soil conditions. The result showed that with each growing season the amount of nitrogen, organic carbon and plant-available phosphorus increased in the soil significantly. This improvement of the soil fertility is the indication of suitability of the species for the process of afforestation in some distressed lands.⁴³

4. Side effects

Based on the study, no harmful side effects such as growth delayed or induction of abnormalities were observed in humans or rats, even with the use of high dosages of the extracts.⁴⁴ A report on the study on the pollen of *E. angustifolia* L. shows that the inhalation

of these allergens may cause nasal irritation symptoms in some sensitized patients.⁴⁵

5. Conclusion

The reports of many studies about *E. angustifolia* L. plant and its extracts have provided a scientific validation for the traditional use of this plant as a remedy for the relief and cure of many common symptoms and problems as well as some other more serious diseases. The plant extracts have shown to have an anti-oxidant, antimicrobial, antimutagenic, and some other therapeutic properties which can contain preventative effect in many serious diseases. In addition planting oleaster trees in distressed areas have shown the increase of soil nutrients and eventually higher agriculture production, with each growing season. Further investigation on the bioactive elements of *E. angustifolia* L., their properties, their effectiveness and safety of this plant is useful and could be considered in the development of pharmaceutical and food products using this plant in the future.

Conflict of interest

Authors declare no conflict of interest.

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